DTS0656-0

EXPLOSION PROTECTION:
background,
types of protection,
intrinsic safety

GM INTERNATIONAL
TECHNOLOGY FOR SAFETY

TORMATICS A/S

TECHNOLOGY FOR SAFETY

Definitions (*IEC 60079-10-1*)

- **Explosive atmosphere:** mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour, dust, fibres, or flyings which, after ignition, permits self-sustaining propagation.
- **Hazardous Area (gas):** an area in which an explosive gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment.

Fire triangle

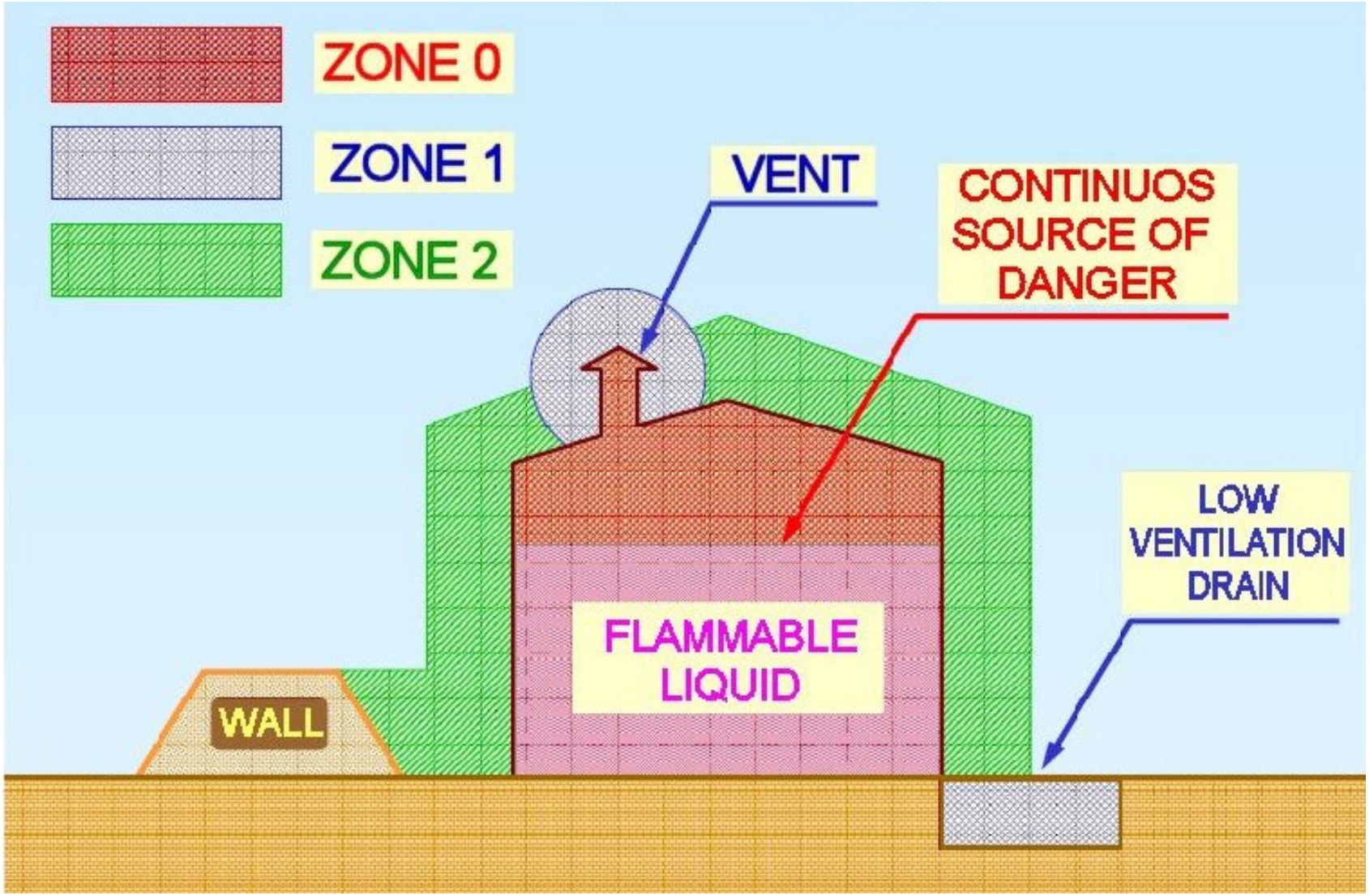
Explosion pentagon

Groups, Categories, Zones, EPLs

Protection level	Presence	Explosive atmosphere	99/92/CE (ATEX)	94/9/CE (ATEX)		IECEx	
			Area classification	Group	Eq. Category	Group	EPL
VERY HIGH (two independent faults)	Long periods / continuously	Coal mine	-	I	M1	I	Ma
		Gas	zone 0	II	1G	II	Ga
		Dust	zone 20	II	1D	III	Da
HIGH (one fault)	Occasionally during normal operation	Coal mine	-	I	M2	I	Mb
		Gas	zone 1	II	2G	II	Gb
		Dust	zone 21	II	2D	III	Db
NORMAL	Not during normal operation	Gas	zone 2	I	3G	I	Gc
		Dust	zone 22	II	3D	II	Dc

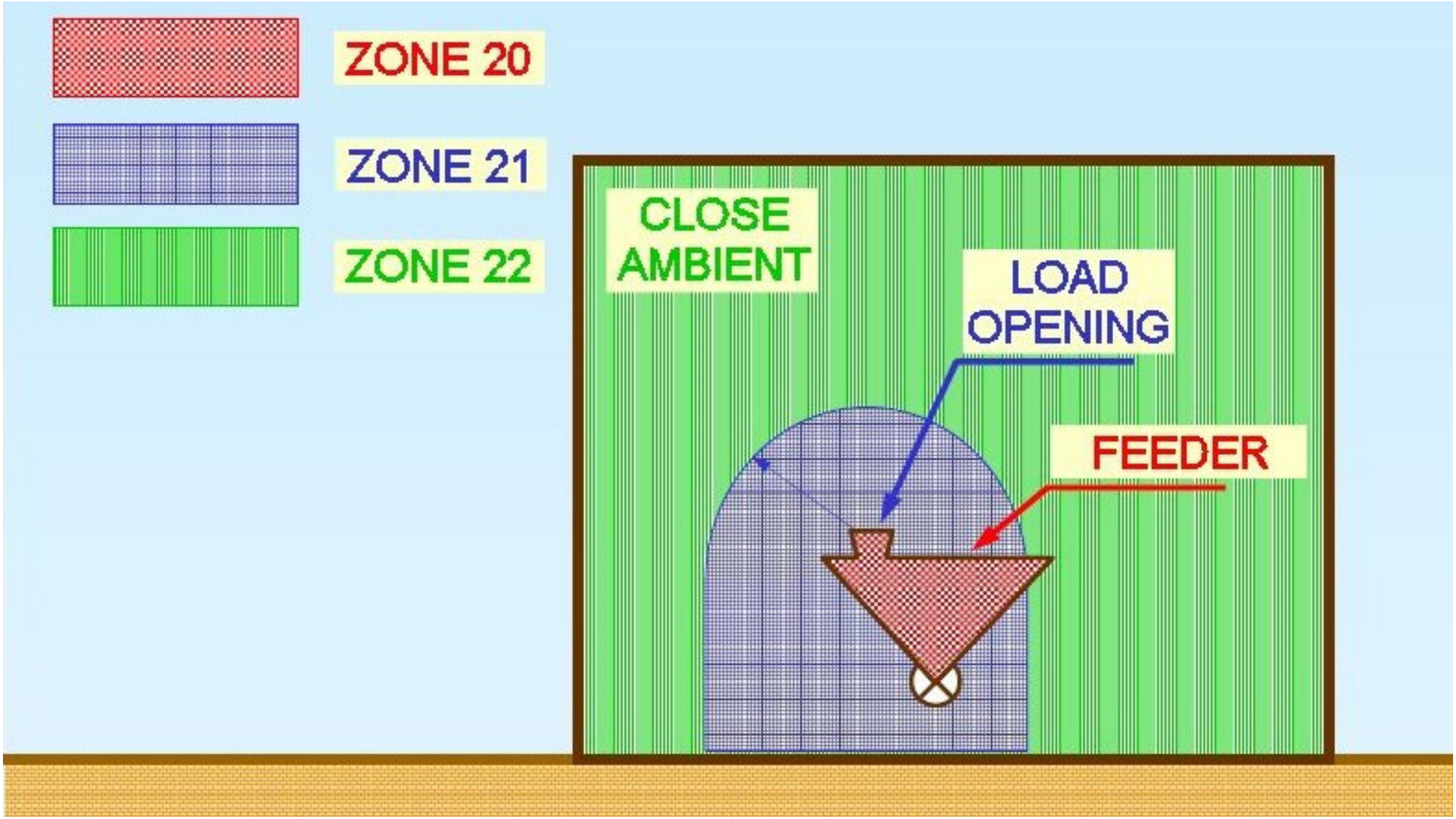
Area classification derived from IEC 60079-10-1 (for gas) and IEC 60079-10-2 (for dust).

Area Classification: example



Gas area classification

Area Classification: example



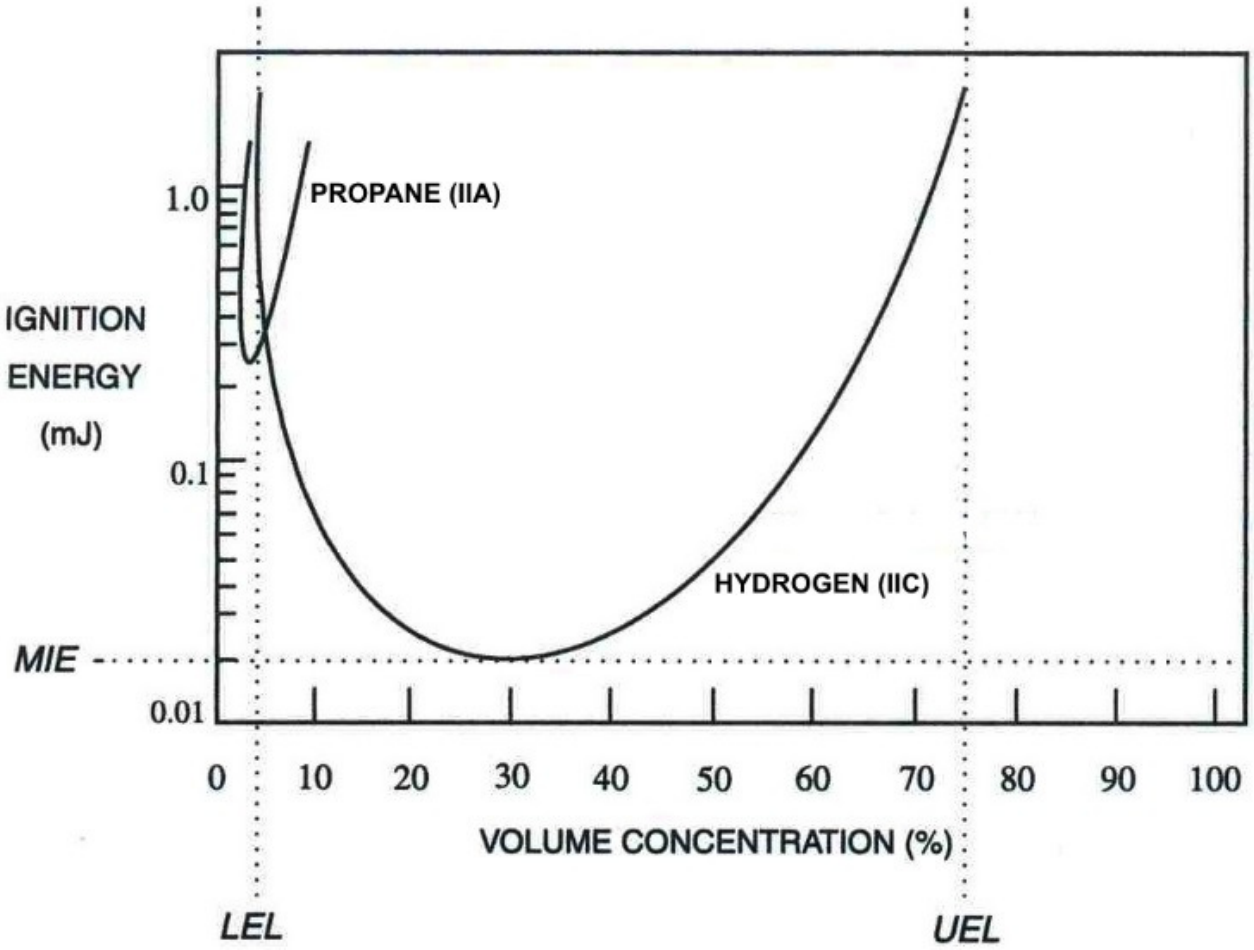
Dust area classification

Gas and Dust Groups

Place of use	Group	Representative substance
Mines susceptible to firedamp	I	methane
Surface industries	IIA	propane
	IIB	ethylene
	IIC	hydrogen/acetylene
	IIIA	combustible flyings
	IIIB	non-conductive dust
	IIIC	conductive dust

Minimum Ignition Energy

Ignition energy vs. gas mixture concentration:



Minimum ignition energy:

I ≈ 320 µJ (methane)

IIA ≈ 180 µJ (propane)

IIB ≈ 60 µJ (ethylene)

IIC ≈ 20 µJ (hydrogen)

DANGER

Graph taken from «North American Guide to Intrinsic Safety», Elcon Instruments

Temperature Class (gas)

Temperature class (°C)	Max surface temperature	Gas or vapour (examples)	Ignition temperature (°C)
T1	450	Methane (I) Hydrogen (IIC) Benzene (IIA)	595 560 496
T2	300	Buthane (IIA) Ethylbenzene (IIA)	372 431
T3	200	Cyclohexane (IIA) Heptane (IIA)	244 204
T4	135	Ethylether (IIB)	175
T5	100		
T6	85	Carbon disulfide (IIC)	90

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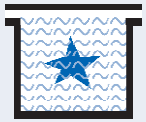
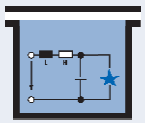
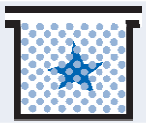
Data taken from IEC 60079-20-1

Ignition energy and ignition temperature are not mutually related!

Types of protection and Standards

Principle	Denomination	Concept	Symbol	Marking	Standard
Segregation	Encapsulation		«m»	Ex ma; Ex mb; Ex mc	EN/IEC 60079-18
	Oil immersion		«o»	Ex o	EN/IEC 60079-6
	Pressurization		«p»	Ex px; Ex py; Ex pz	EN/IEC 60079-2
Prevention	Increased safety		«e»	Ex e	EN/IEC 60079-7
	Intrinsic safety		«i»	Ex ia; Ex ib; Ex ic	EN/IEC 60079-11
Containment	Flameproof		«d»	Ex d	EN/IEC 60079-1
Quenching	Powder filling		«q»	Ex q	EN/IEC 60079-5
Simplified	Non incendive		«n»	Ex nA; Ex nC; Ex nR	EN/IEC 60079-15

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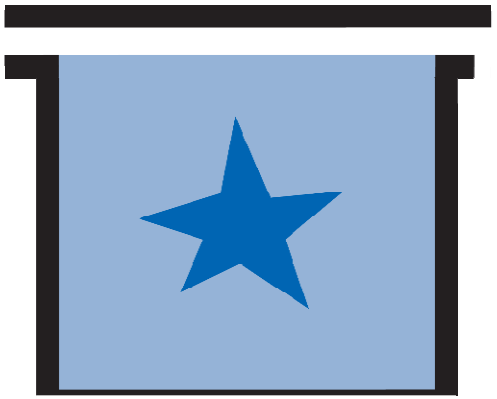
Encapsulation «Ex m»

Basic principle: segregation

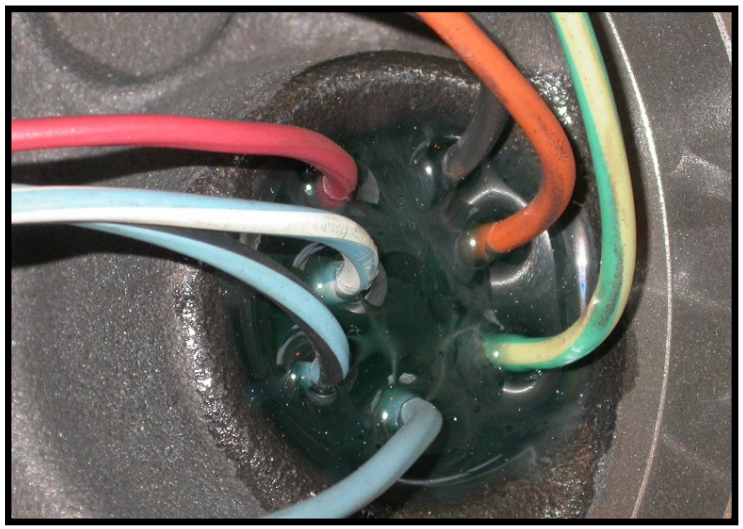


Characteristics:

- good mechanical protection
- maintenance and/or reparation not possible!

Applications:

- small size apparatus (transformers, electrovalves, electronic sensors and devices)

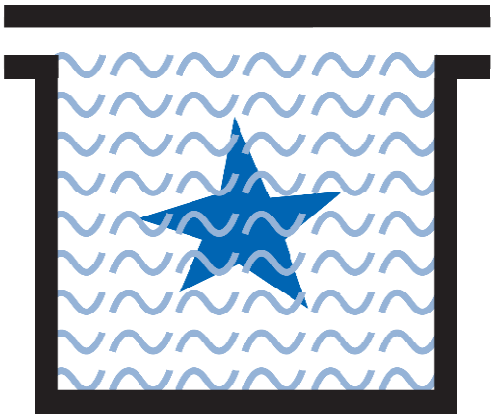


Oil immersion «Ex o»

Basic principle: segregation

Characteristics:

- oil with good isolating characteristics
- not favorable for small devices



Applications:

- power transformers
- motors
- contacts and moving electrical parts

Pressurization «Ex p»

Basic principle: segregation

Characteristics:

- no size limitation, but not favorable for small devices
- safety related control necessary
- necessary when source of emission is within apparatus (gas analyzers)

Applications:

- transformers
- big motors
- instrumentation panels
- analysis cabins and pressurized rooms

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Increased safety «Ex e»

Basic principle: prevention

Characteristics:

- increased insulation materials
- degree of protection
- limited overtemperatures

Applications:

- terminal blocks
- coils
- motors and generators
- lighting appliances
- batteries and trace heating resistances

Intrinsic safety «Ex i»

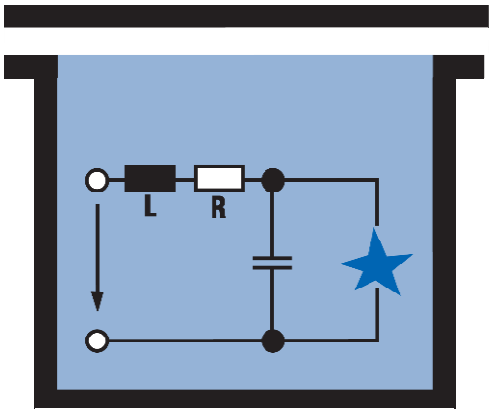
Basic principle: prevention

Characteristics:

- low power applications
- overrated components
- safety factors
- isolation distances
- need of barrier (system integrity)

Applications:

- electronic instruments
- measurement and control processes
- battery supplied devices



Flameproof «Ex d»

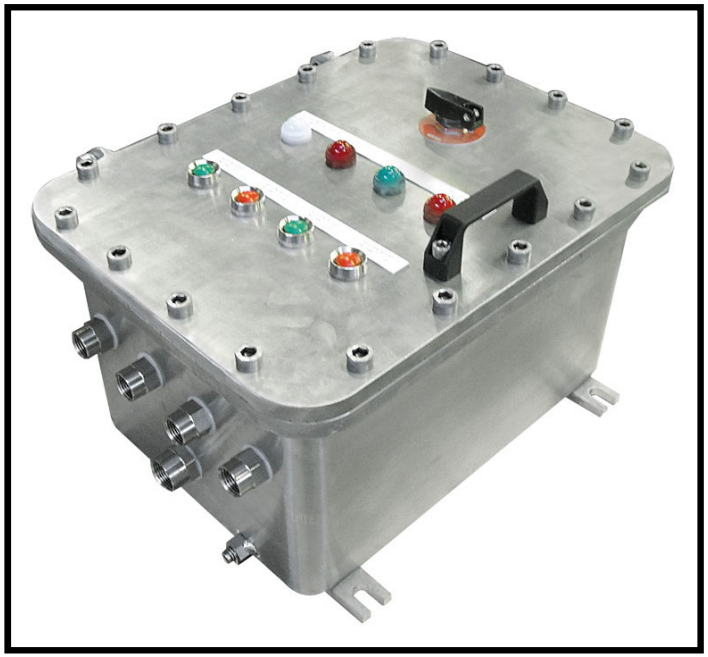
Basic principle: containment

Characteristics:

- metallic material enclosures:
  - ✓ constructional stability
  - ✓ long reliability
- non-metallic material enclosures:
  - ✓ very small volumes

Applications:

- switches
- lighting appliances
- motors
- switchgears and controlgears

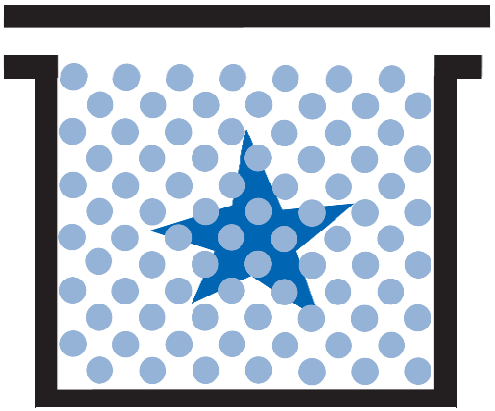


Powder filling «Ex q»

Basic principle: quenching

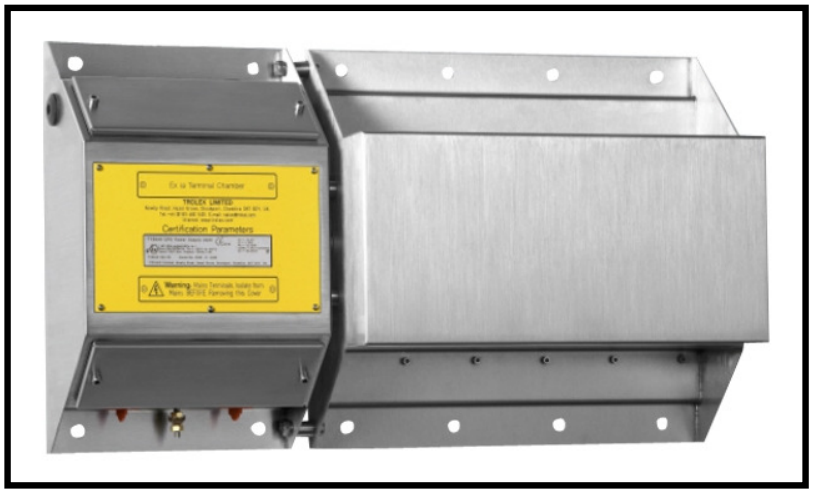
Characteristics:

- powder with good dielectric characteristics (quarts/sand)
- enclosure withstanding pressure



Applications:

- power supplies
- traction batteries
- discrete sub-assemblies and components inside other apparatus (generally Ex e)



«Ex n»

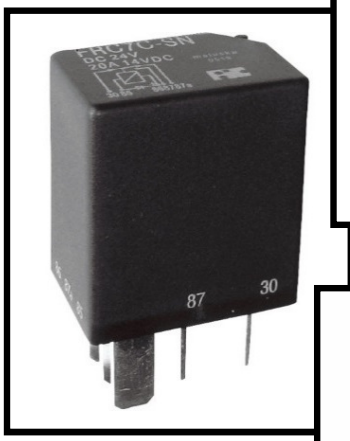
Basic principle: various

Characteristics:

- only for normal operating conditions
- only for zone 2, EPL Gc
- Ex nA, Ex nC, Ex nR

Applications:

- motors
- lighting appliances
- terminal blocks
- single sparking devices (relays, bi-metallic switches)



Historical Information

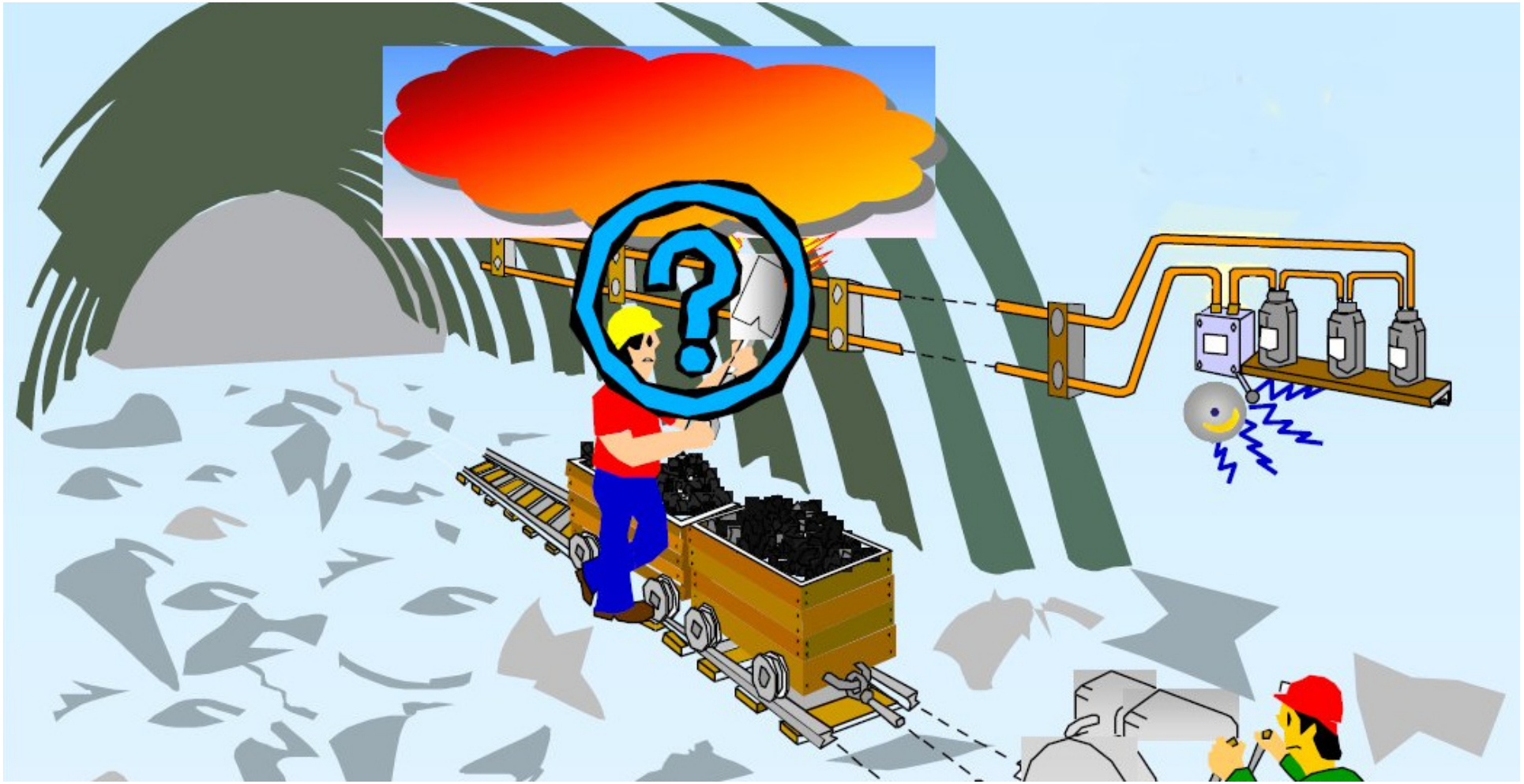
Mines were the first area taken into consideration for explosion risks due to the presence of Griseous Gas and Carbon Dust.

An electrical spark could ignite the gas generating a primary explosion which would create a secondary carbon dust explosion propagating trough the mine with disastrous effects.

Already in the late 1800 beginning of the 1900 hundred low voltage batteries were used in mines to prevent electrical spark.

But this was not a safe circuit.

Historical Information



«Safe» low voltage signaling system

Historical Information


The Daily Mirror 20 Pages

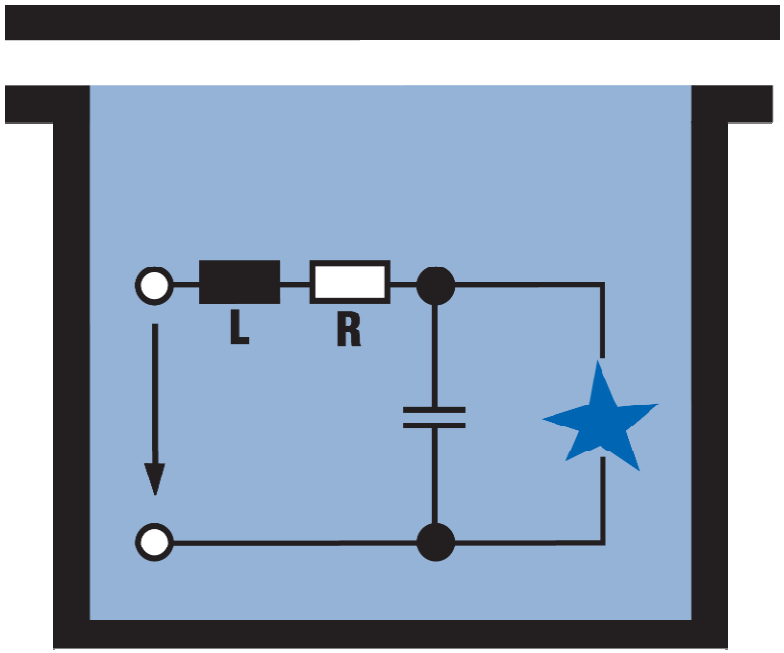
TRAPPED IN A BLAZING MINE: "WORST DISASTER IN THE HISTORY OF THE WELSH COALFIELDS."

After a 1913 huge mine explosion in a Welsh mine that left 439 dead miners, studies begin until it was realized that the energy accumulated in the circuit Inductance and Capacitance, even in a low voltage system, could lead to a large enough spark to ignite the gaseous atmosphere present.

Historical Information

This studies lead to an energy limitation technique:

“Intrinsic Safety”.



Historical Information

2000 — Complete development of Intrinsic Safety market. Harmonization of world standards. IEC Ex

1970

1950 — Low use of Intrinsic Safety until the introduction of semiconductor circuits. Development of National Standards

1930 — Extension of studies to cover surface industries substances

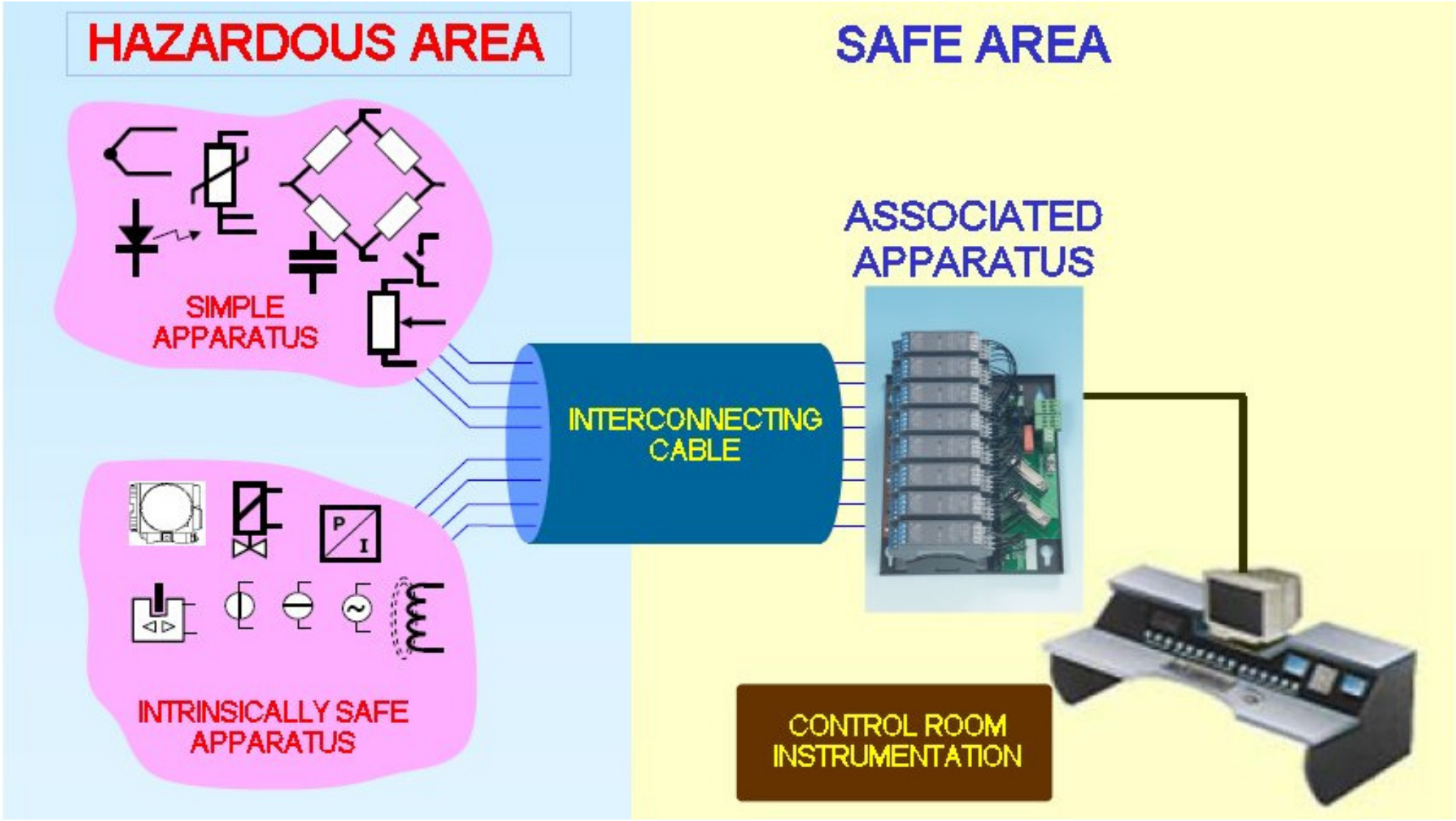
1° Certified Intrinsic Safety Apparatus

1920 — Energy Limitation as the fundament of Intrinsic Safety

Study on ignition mechanism in methane-air gas mixtures

1910

Intrinsic Safety Loop



Intrinsic safety is always implemented as a loop

Entity Parameters

The use of an Isolator or a Barrier is not a sufficient condition to achieve Safety in Hazardous Locations.

The system (loop) must be verified as a whole:

- Isolator / Barrier Certification in compliance with Area
- Field Device Certification in compliance with Area
- Safety parameters of Apparatus and Associated Apparatus must match
- Cable length, its parameters, must be in compliance with Associated Apparatus certificate

Entity Parameters

Associated Apparatus (Isolators/Barriers):

- Um Maximum allowed voltage on Safe Area Circuits
- Uo Maximum Open Circuit Voltage
- Io Maximum Short Circuit Current
- Po Maximum Transferable Power
- Co Maximum External Capacitance Allowed
- Lo Maximum External Inductance Allowed
- Lo/Ro Maximum Allowed External L/R Ratio

Entity Parameters

Apparatus (Field Instruments):

- Ui Maximum Allowed Open Circuit Voltage
- Ii Maximum Allowed Short Circuit Current
- Pi Maximum Allowed Power
- Ci Maximum Internal Capacitance
- Li Maximum Internal Inductance

Entity Parameters

Cable:

- Cc Cable Capacitance x Length (mt or km)
- Lc Cable Impedance x Length (mt or km)
- Lc/Rc Cable Impedance Vs. Resistance Ratio

Entity Parameters verification

THH200			G.M. D5014
Ui (30 V)		>	Uo (25.9 V)
Ii (130 mA)		>	Io (92 mA)
Pi (800 mW)		>	Po (594 mW)
Ci (0.005 µF)	+ Cc	<	Co (0.1 µF)
Li (0.5 mH)	+ Lc	<	Lo (4.2 mH)

http://www.gminternationalsrl.com/index.php?p=loop_check

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Certification tools: Loop Verificator

Ex loop safety parameters verification

Home > Software > Ex loop safety parameters verification

List of saved loops: ABB TTH200 example (ID: 2651; Date: June 8, 2015) Resume data

ASSOCIATED ELECTRICAL APPARATUS		
Manufacturer	G.M. International S.r.l.	
Product	D5014S Ch1 - term. 7-8	
INTRINSICALLY SAFE APPARATUS		
• In case of Simple Apparatus (not certified), please set Ui, Ii, Pi, Ci, Li as 'not mentioned in certificate'		
Manufacturer (optional)	ABB	
Equipment type (optional)	TTH200	
Certificate (optional)	PTB 05 ATEX 2017 X	
Protection Method (optional)	II 1G Ex ia IIC T6	
Max. open circuit voltage (Ui)	30 V	not mentioned in certificate
Max. short circuit current (Ii)	130 mA	not mentioned in certificate
Max. input power (Pi)	800 mW	not mentioned in certificate
Max internal capacitance (Ci)	0.005 µF	not mentioned in certificate
Max internal inductance (Li)	0.5 mH	not mentioned in certificate
CONNECTION CABLE		
• If cable parameters are unknown, the following values may be used: Cc=0.18µF/Km, Lc=0.6mH/Km, Rc=75Ω/Km		
Specific capacitance (Cc)	0.18 µF/Km	
Specific inductance (Lc)	0.6 mH/Km	
Specific resistance (Rc)	75 Ω/Km	
Lenght	100 m	
GAS/DUST GROUP		
Gas/Dust Group	IIC / A,B	
SAVE		
• As an option, al loop information can be saved into your personal account for later use. Specify a name to save.		
Name or description		

Important disclaimer:
This evaluation tool is intended to give the user an indicative verification of the IS Loop based upon on our best knowledge of the latest standards. We remind that Loop Certifications can only be carried out by relevant Notified Bodies, therefore G.M. International does not take any responsability for the results of the above verification.

VERIFY

MANUFACTURER DATA:

ASSOCIATED ELECTRICAL APPARATUS (edit)	
Manufacturer	G.M. International S.r.l.
Product	D5014S Ch1 - term. 7-8
Protection Method	[Ex ia]
Max. open circuit voltage (Uo)	25.9 V
Max. short circuit current (Io)	92 mA
Max. output power (Po)	594 mW
Max allowed external capacitance (Co)	0.05 µF ~~0.1 µF~~ (Note 1)
Max allowed external inductance (Lo)	2.1 mH ~~4.2 mH~~ (Note 1)
Max. inductance/resistance ratio (Lo/Ro)	59.9 µH/Ω

Note 1.
Original Lo and Co values have been divided by half; in fact for installations in which both the Ci and Li of the Intrinsically Safe apparatus exceed 1% of the Co and Lo parameters of the Associated Apparatus (excluding the cable), then 50% of Co and Lo parameters are applicable and shall not be exceeded (50% of the Co and Lo become the limits which must include the cable such that Ci device + C cable = 50 % of Co and Li device + L cable = 50 % of Lo).

INTRINSICALLY SAFE APPARATUS (edit)	
Manufacturer	ABB
Equipment type	TTH200
Certificate	PTB 05 ATEX 2017 X
Protection Method	II 1G Ex ia IIC T6
Max. open circuit voltage (Ui)	30.0 V
Max. short circuit current (Ii)	130 mA
Max. input power (Pi)	800 mW
Equivalent input capacitance (Ci)	0.005 µF
Equivalent input inductance (Li)	0.5 mH
CONNECTION CABLE (edit)	
Specific capacitance (Cc)	0.180 µF/Km
Specific inductance (Lc)	0.6 mH/Km
Specific resistance (Rc)	75.0 Ω/Km
Lenght	100 m
Maximum lenght	528 m
GAS/DUST GROUP	
Gas/Dust Group	IIC / A,B

RESULTS:

	Test	Results	
1.	Uo <= Ui	POSITIVE	✓
2.	Io <= Ii	POSITIVE	✓
3.	Po <= Pi	POSITIVE	✓
4.	Ci+Cc <= Co	POSITIVE	✓
5.	Li+Lc <= Lo	POSITIVE	✓
6.	Lc/Rc <= Lo/Ro	NOT APPLICABLE	

✓ Your loop is verified!

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Associated Apparatus

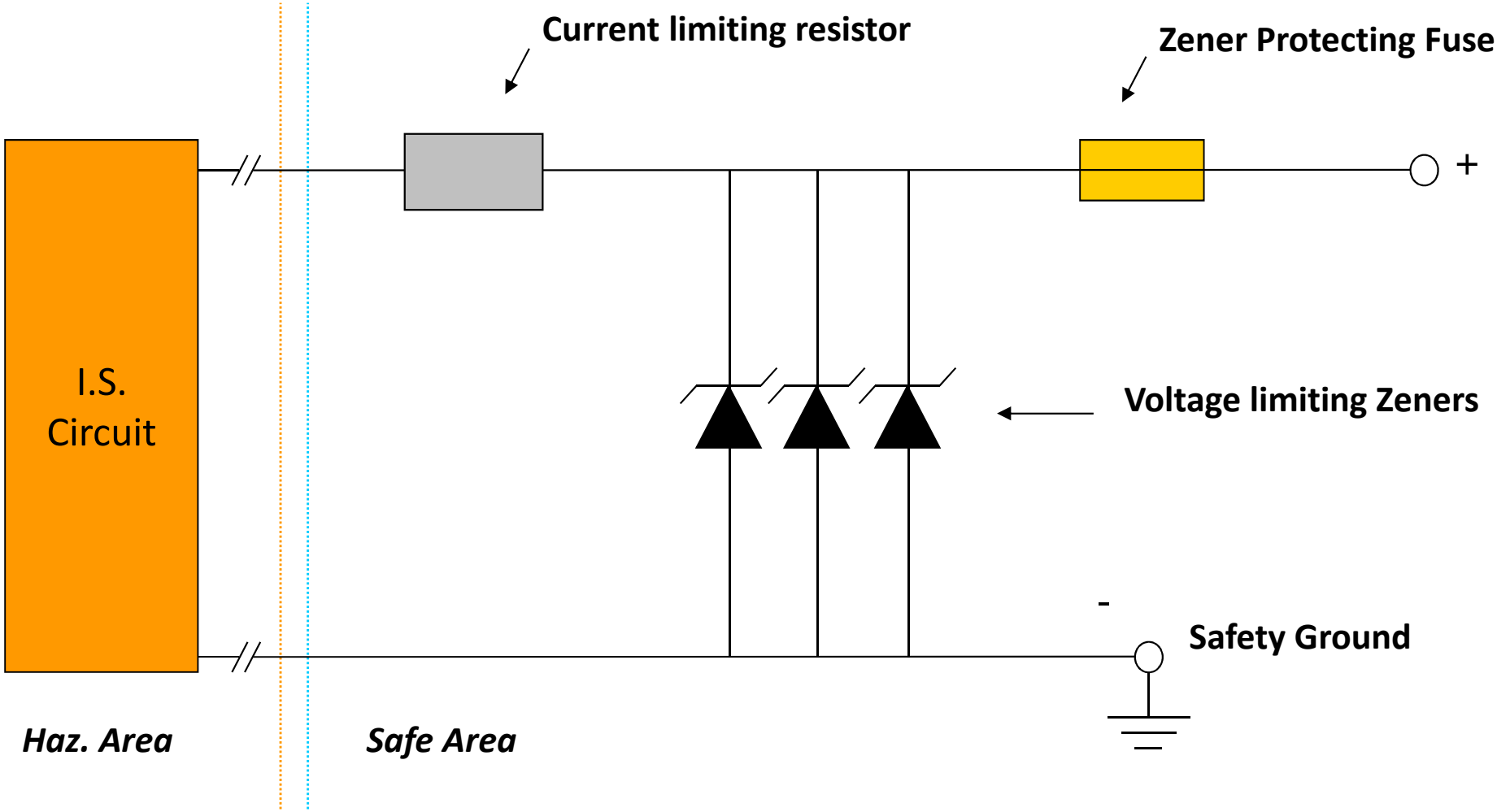
ZENER BARRIERS (Barriers):

Passive devices that use Zener Diodes to divert fault current to ground.

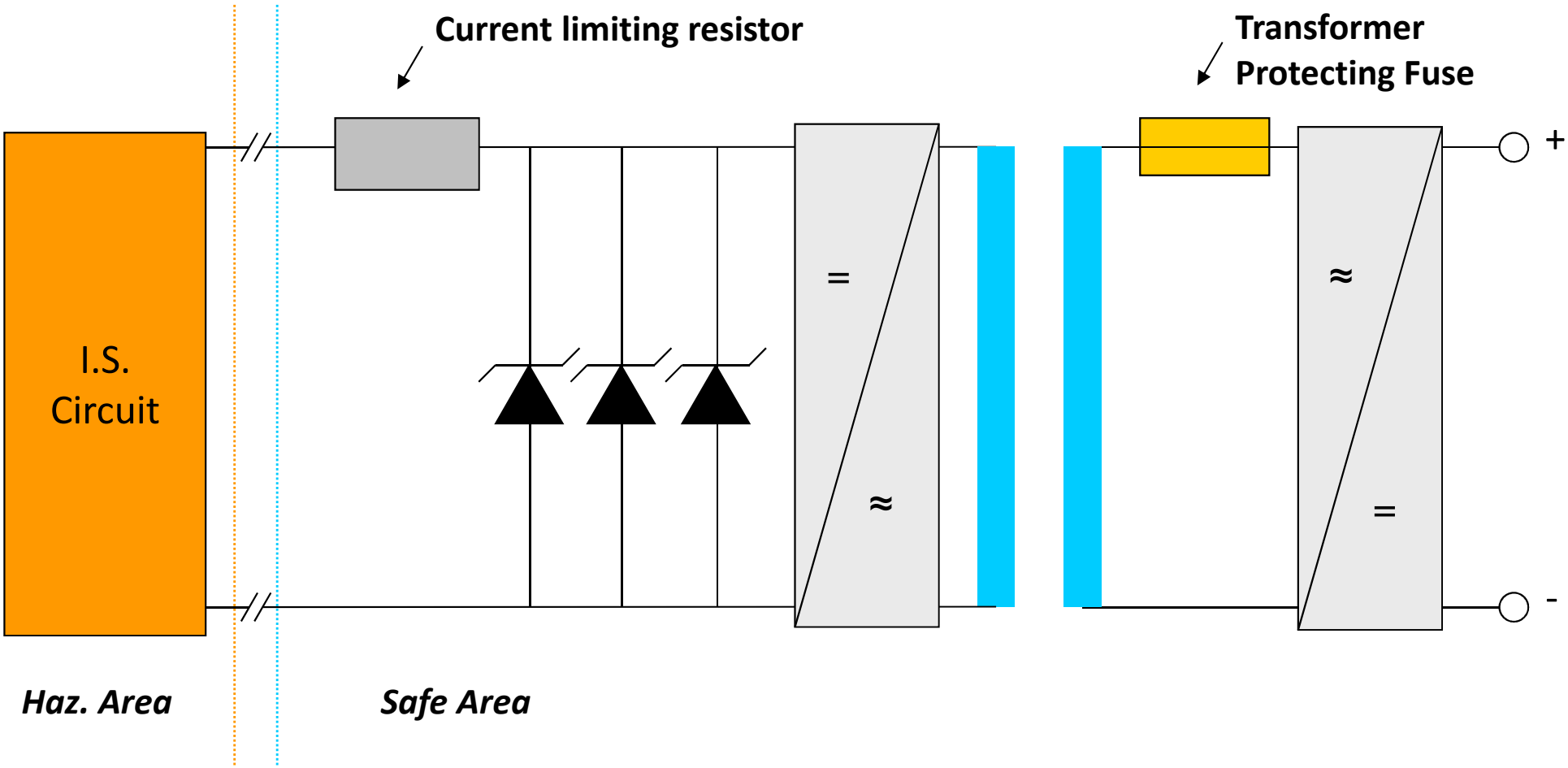
ISOLATED BARRIERS (Isolators):

Active instruments that use Safety Isolation components, such as transformers or opto-couplers, to keep a fault energy to pass from Safe to Hazardous Location.

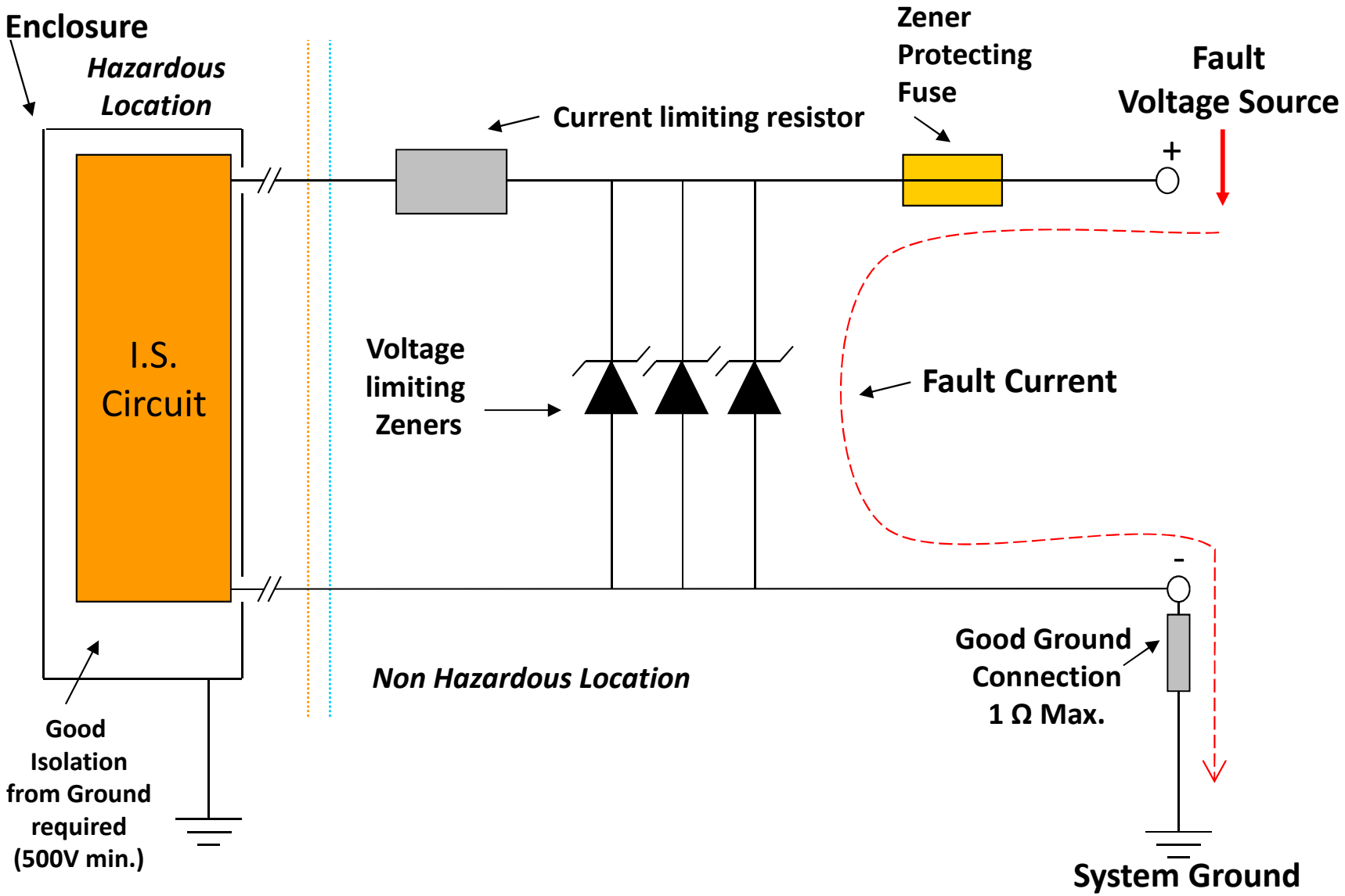
Zener barrier



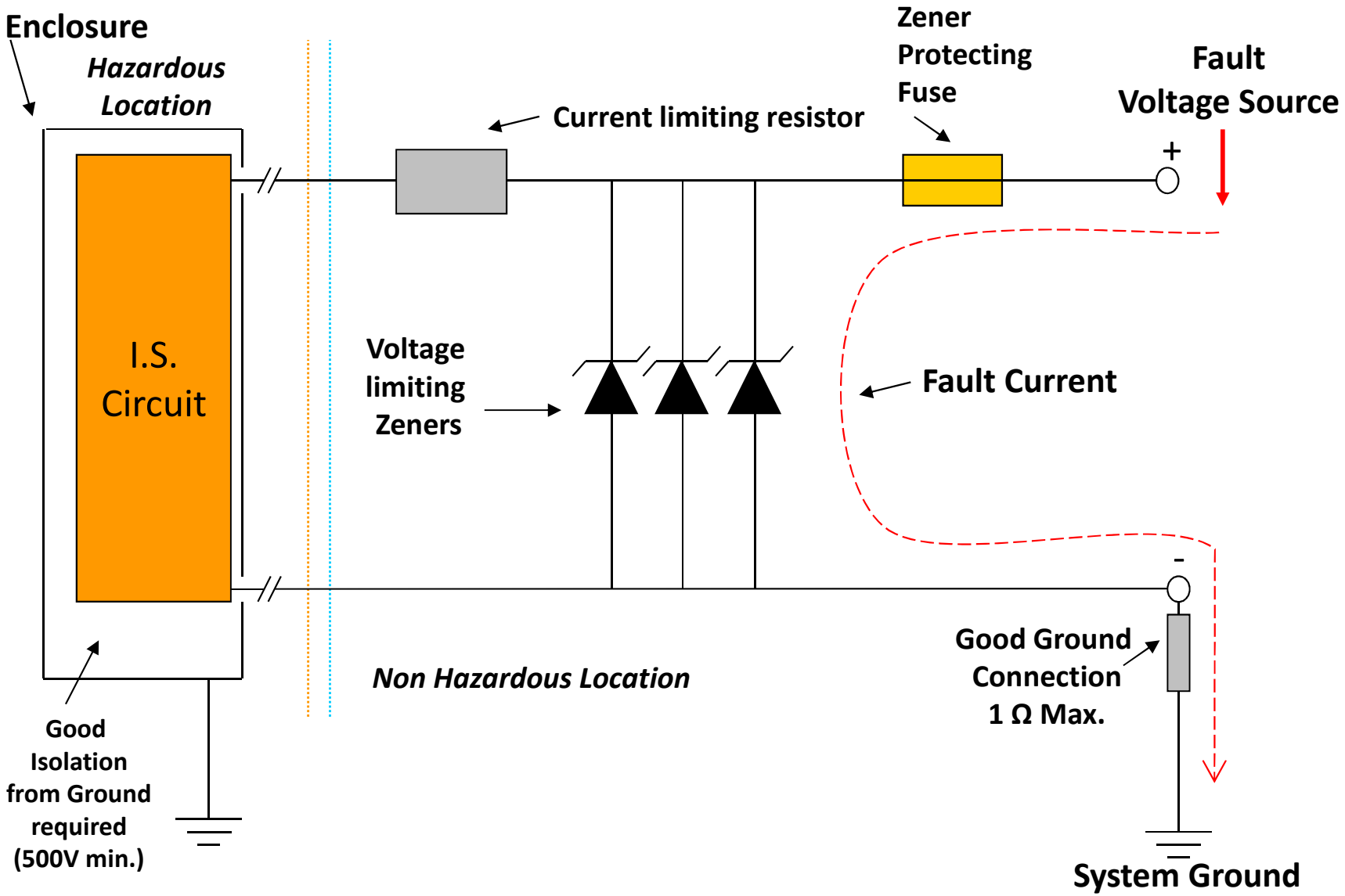
Isolated barrier



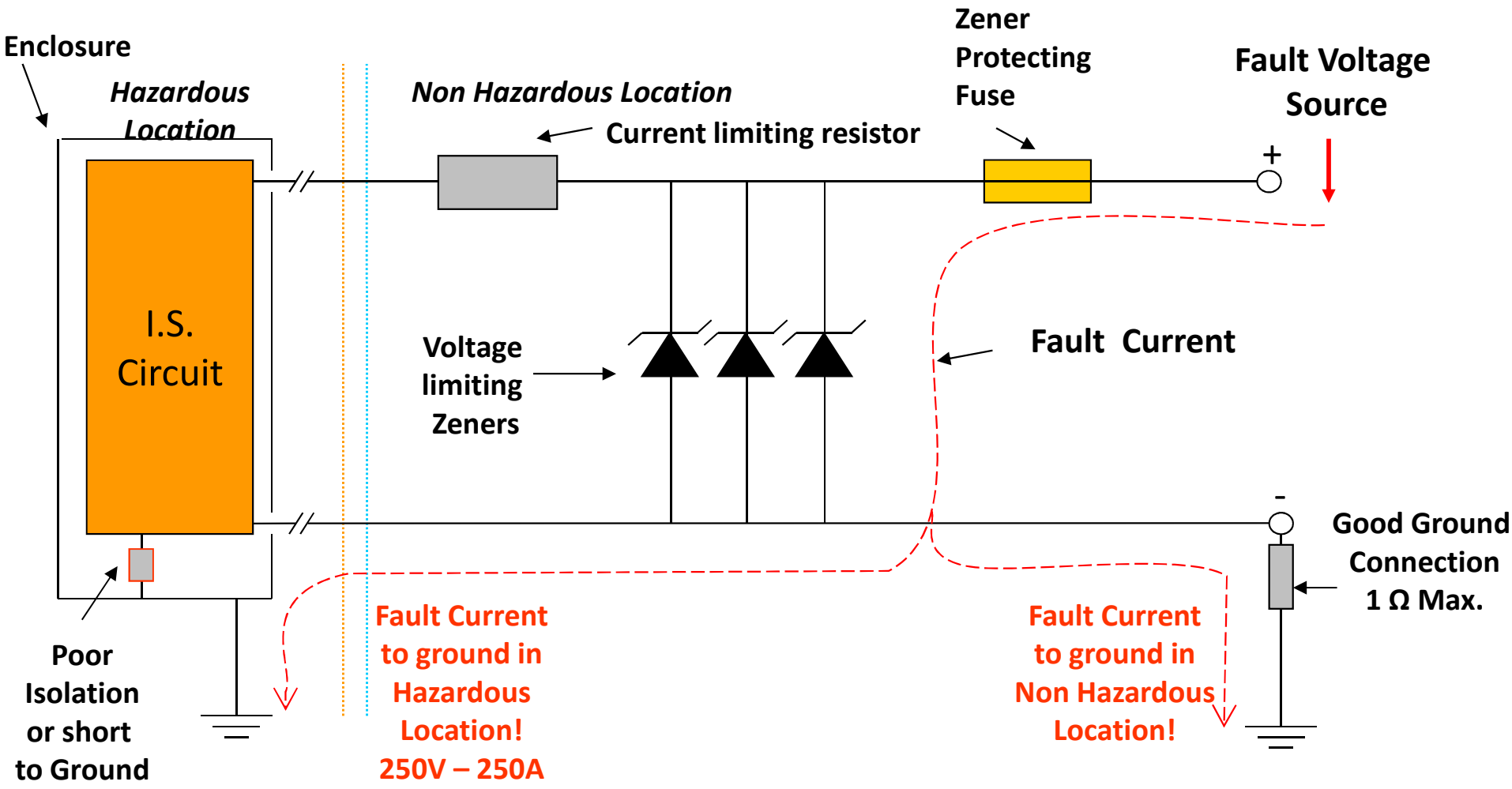
Zener barrier principles



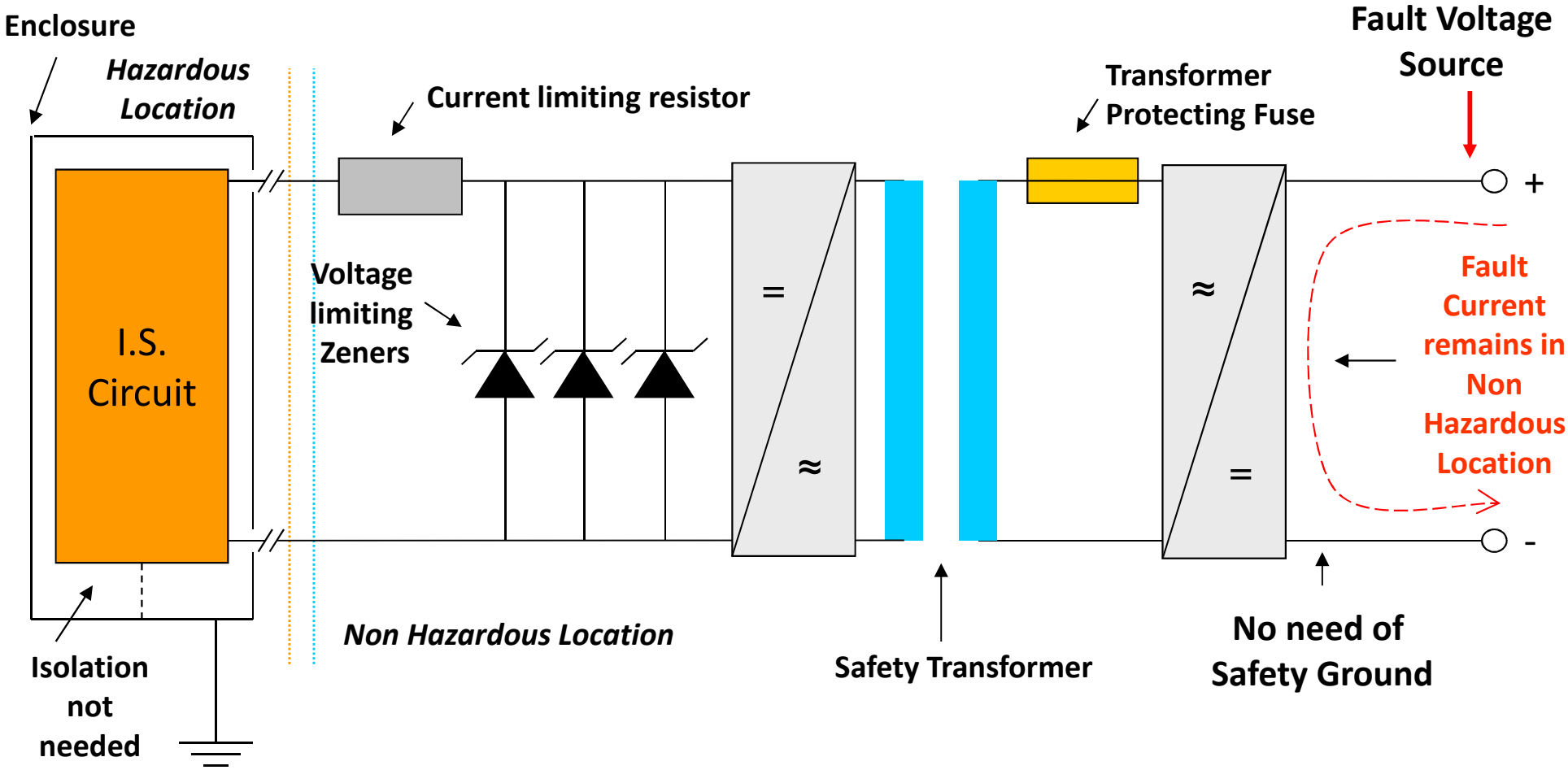
Galvanic Isolator principles



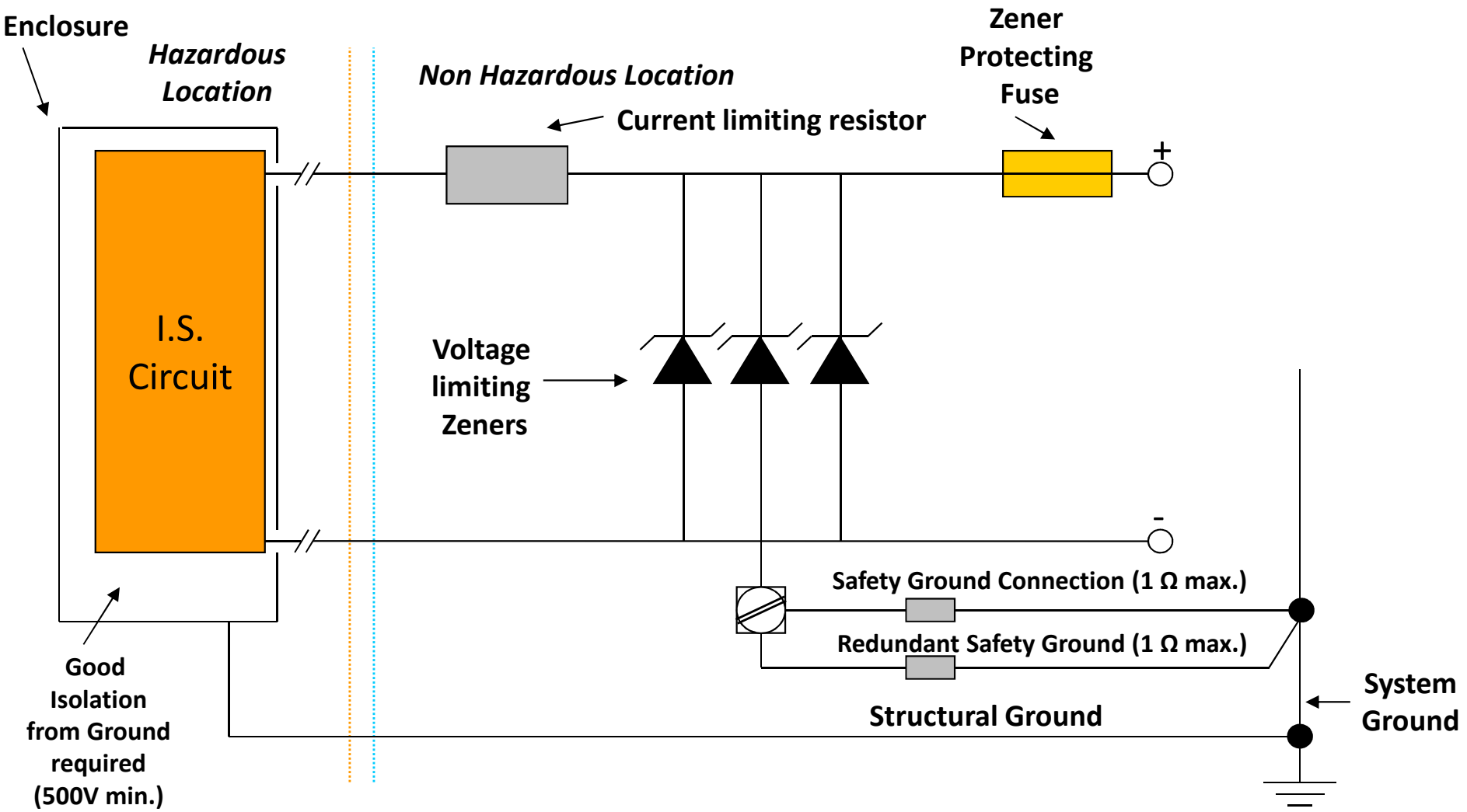
Protection under fault condition - Barriers



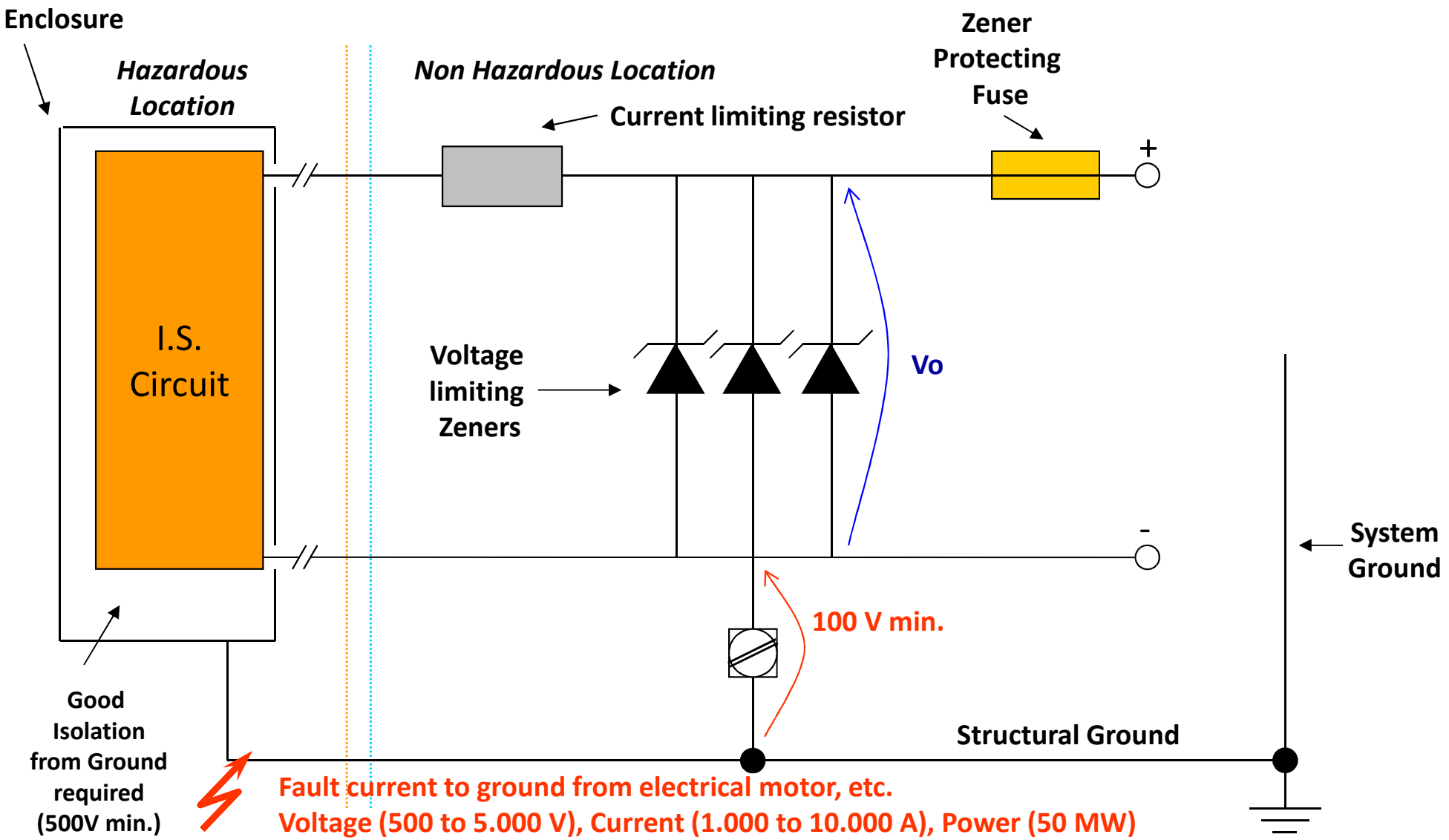
Protection under fault condition - Isolators



Grounding Condition - Barriers



Independent grounding reasons - Barriers



Zener Barriers

ADVANTAGES

- Lower parts cost
- Elementary three components device

DISADVANTAGES

- Dedicated Safety Ground Cost
- Safety Depends on
  - ✓ Good Safety Ground
  - ✓ Good Lines Isolation
- Voltage Drop across Resistor
- Zeners leakage Infl. accuracy
- Isolation of lines Infl. Accuracy
- Requires routine Checks.
- Grounded non linear semi-conductor (Zener) reduces immunity to inter-ferences (common mode rejection)
- Applicable only with sensors that are well isolated from ground (500 V)

Isolated Barriers

ADVANTAGES

- No Safety Ground requirement (No cost / No maintenance)
- Safety not impaired by a fault to ground.
- Full voltage availability.
- Better overall accuracy
  - ✓ Zener Leakage does not affect accuracy
  - ✓ Isolation of lines does not affect accuracy
- Higher common mode rejection and immunity to interferences
- Allows the use of grounded or poorly isolated sensors

DISADVANTAGES

- Higher part cost